Machine Learning and Artificial Intelligence

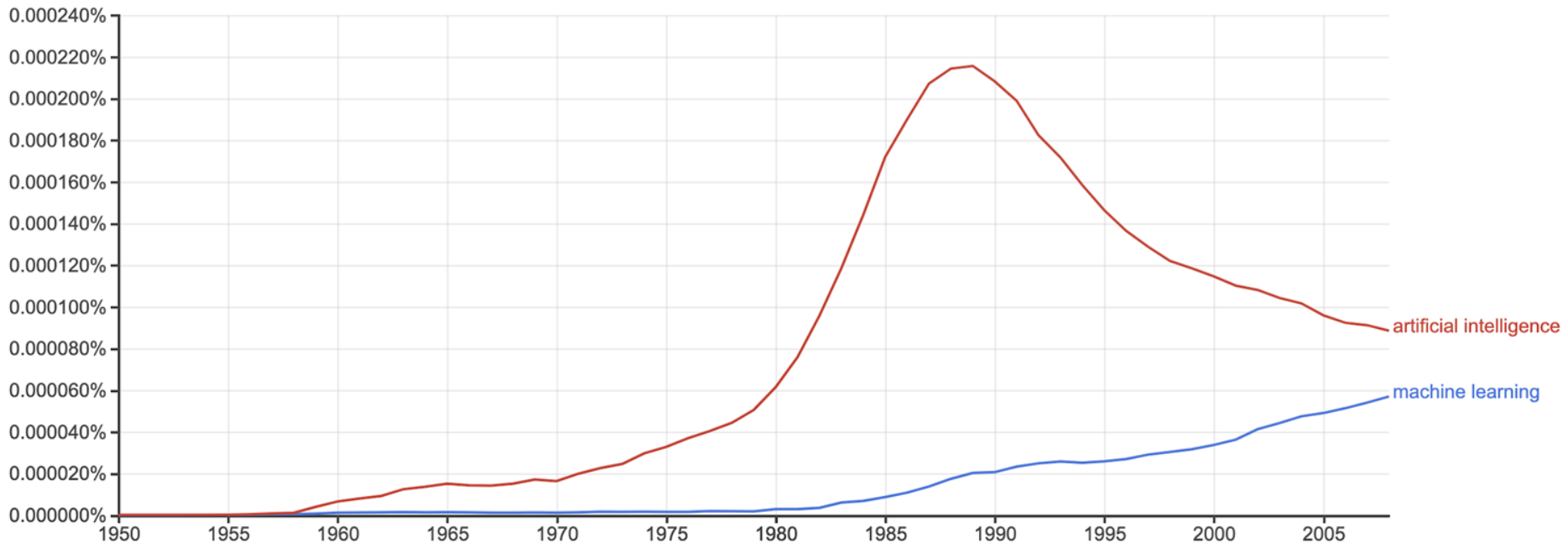
“Programming agents by hand can be very tedious; some more expeditious method seems desirable.”

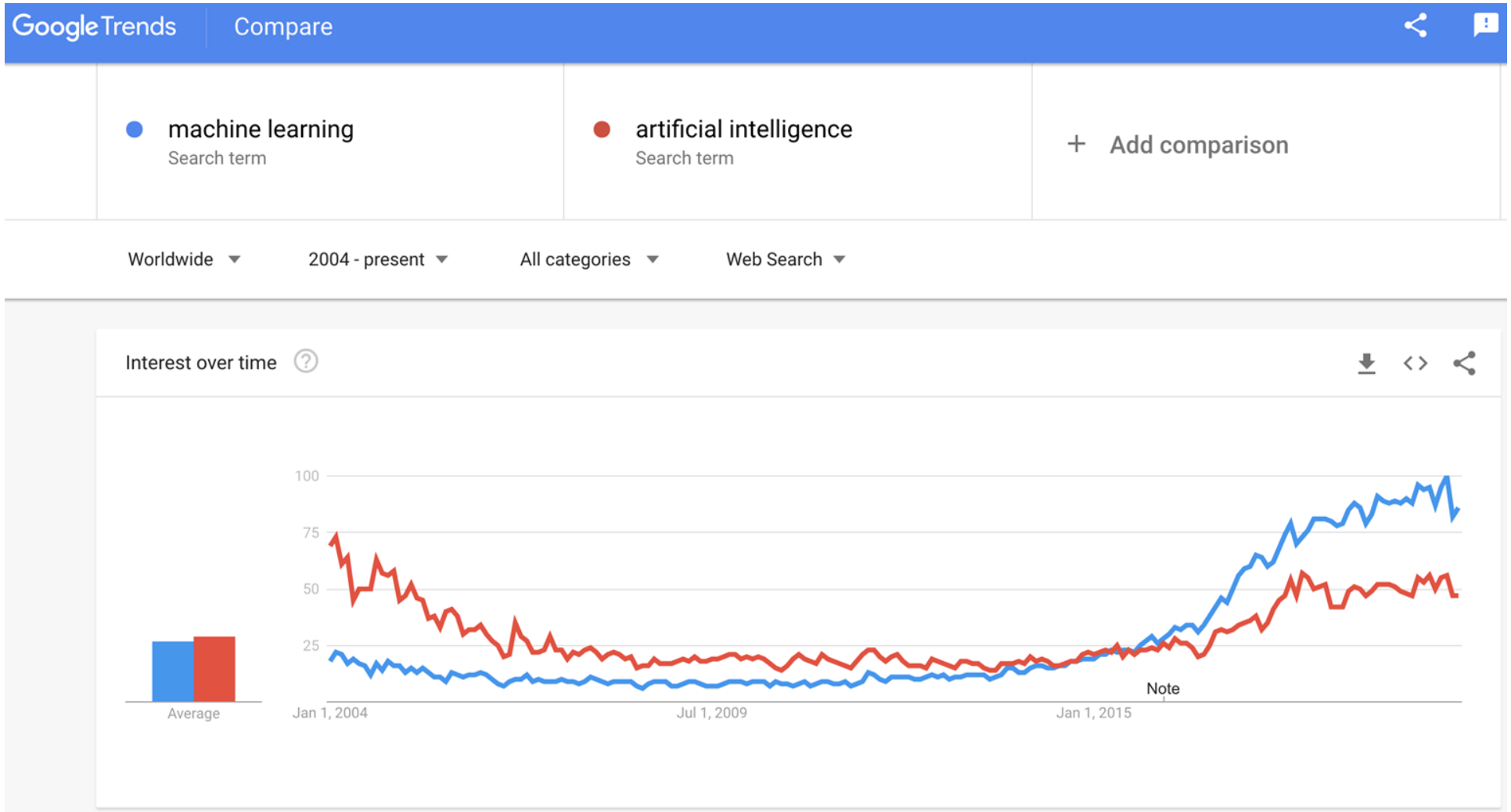
—Alan Turing, 1950

Google Books Ngram Viewer

Graph these comma-separated phrases: machine learning,artificial intelligence case-insensitive

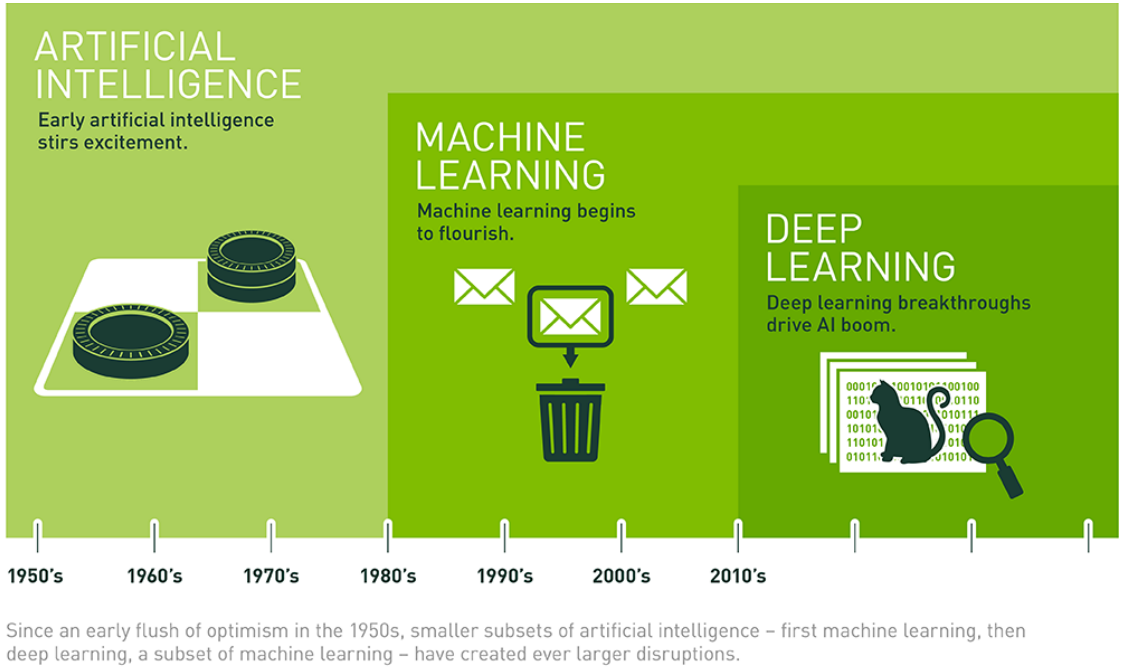
between 1950 and 2008 from the corpus English (2012) with smoothing of 3 . Search lots of books




Google Trends
Compare
machine learning
Search term
artificial intelligence
Search term
+ Add comparison
Worldwide
2004 - present
All categories
Web Search
Interest over time
100
75
50
25
Note
Average
Jan 1, 2004
Jul 1, 2009
Jan 1, 2015

ML and AI

- Artificial Intelligence
  - Computational rationality
  - Decision making under uncertainty
- Machine Learning (ML)
  - Finding patterns in data



Since an early flush of optimism in the 1950s, smaller subsets of artificial intelligence – first machine learning, then deep learning, a subset of machine learning – have created ever larger disruptions.

Source

Autonomous Driving

Autonomous Driving

- **Object identification**
- **Object detection**
- **Object tracking/prediction**
- **Route planning**
- **Fully autonomous driving**

Autonomous Driving

Artificial Intelligence

- **Object identification**
- **Object detection**
- **Object tracking/prediction**
- **Route planning**
- **Fully autonomous driving**

Autonomous Driving

Object identification	Image → Label
Object detection	Image → Object bounding boxes
Object tracking/prediction	Video → Moving bounding boxes
Route planning	Video, Map, Coordinates → Actions
Fully autonomous driving	Video, Map, Coordinates, Ethics, … → Actions

Autonomous Driving

Classical Machine Learning

Object identification	Image → Label
Object detection	Image → Object bounding boxes
Object tracking/prediction	Video → Moving bounding boxes
Route planning	Video, Map, Coordinates → Actions
Fully autonomous driving	Video, Map, Coordinates, Ethics, … → Actions

Supervision

- Supervised learning (inputs, labels)
- Unsupervised learning (inputs)
- Reinforcement learning (inputs, eventual rewards)

The End

Course Overview

Machine Learning Is Going Mainstream

- “Data is the new oil.”
- “AI is the new electricity.”
- “Privacy is the new luxury.”
- “Machine learning is the future.”

Course Goals

- Practical introduction to the machine learning field
- Building blocks and theory of neural networks
- Useful programming tools (including Tensorflow)
- Learn how to stay current as the field changes

Python Notebooks

- Weekly notebooks are the interactive textbook of this course
- Options for running the code
  - Run locally using Jupyter (need to install libraries)
  - Run using Google’s Colab (everything is installed)

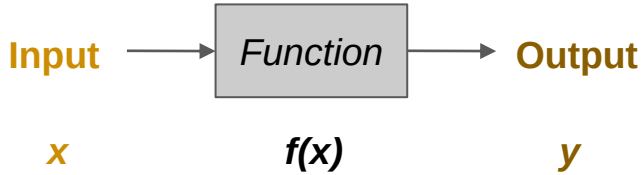
Course Work

- Weekly notebook exercises
- Final project
  - Small groups
  - Choose from approximately three Kaggle competitions
  - Run experiments
  - Write a summary report and present to class

The End

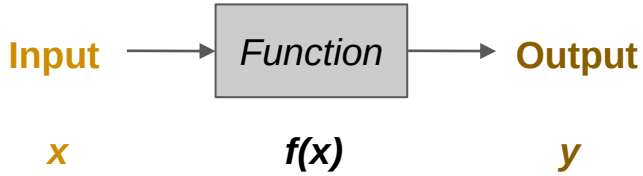
What Is a Function?

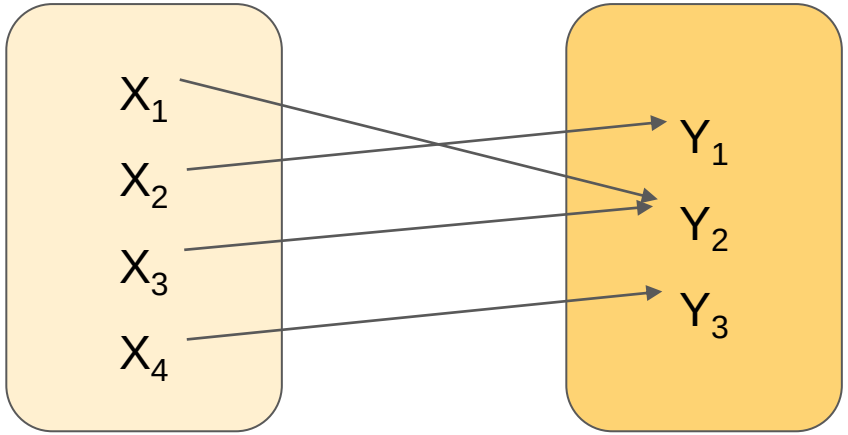
What Is a Function?



What Is a Function?

Mapping between sets: for each input item, there is one corresponding output item.





Function Examples

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- add_six(number)
- get_prime_factors(number)
- upper_case(string)
- convert_time(loc1, time, loc2)
- is_it_raining(weather_report)

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- is_it_raining(weather_report)
- height_from_shoe_size(shoe_size)
- is_cat(image)
- is_positive_movie_review(text)
- text_from_audio(audio)
- will_it_rain_tomorrow(weather_report)

Learned Functions (Models)

How would you write this function:

height_from_shoe_size(shoe_size)

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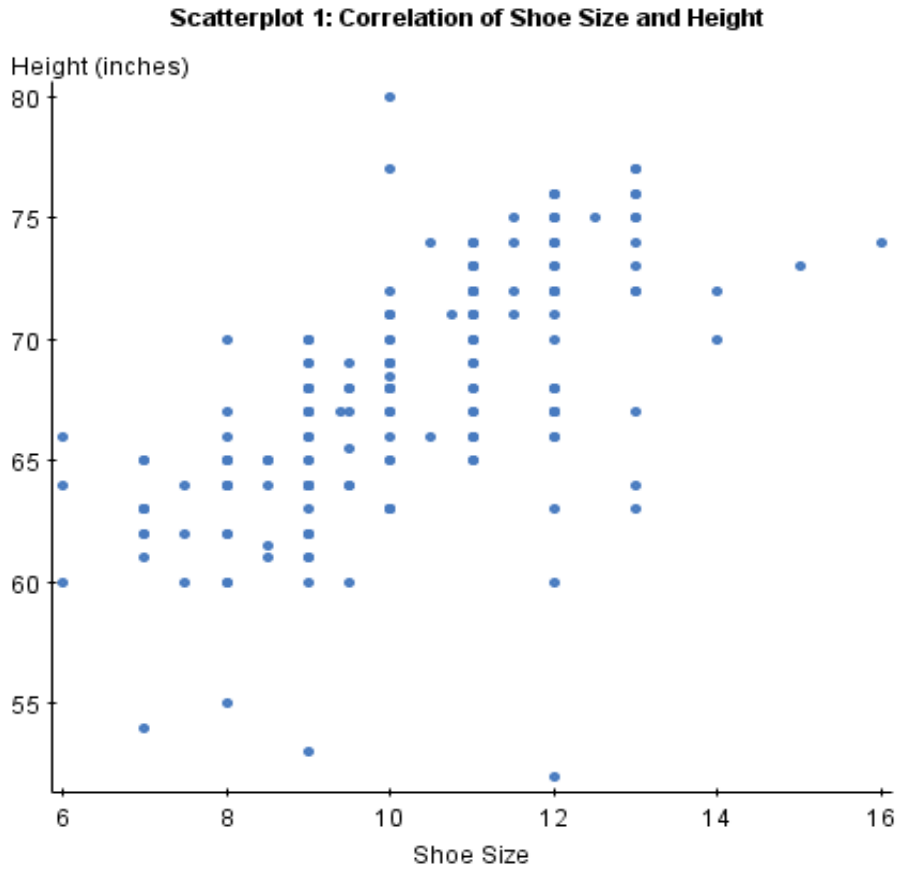

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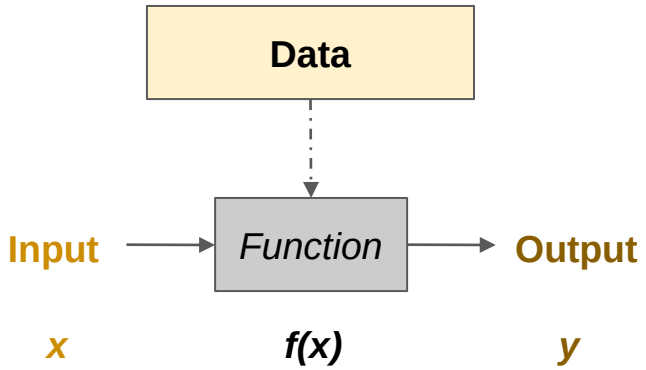

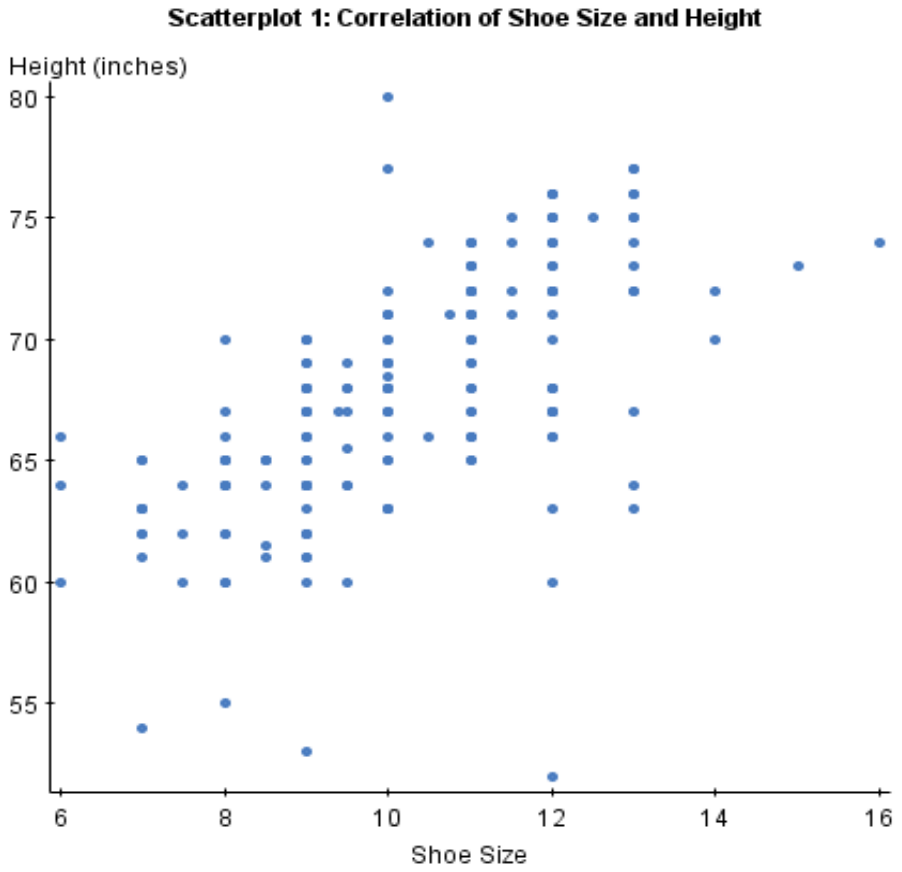

The End

Function Testing

Function Testing

```
def add_six_test():
        ???
```

Function Testing

```
def add_six_test():
        assertEqual(add_six(-3),
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        assertEqual(add_six(3), 9)
```

- Testing logic
- Check edge cases

Function Testing

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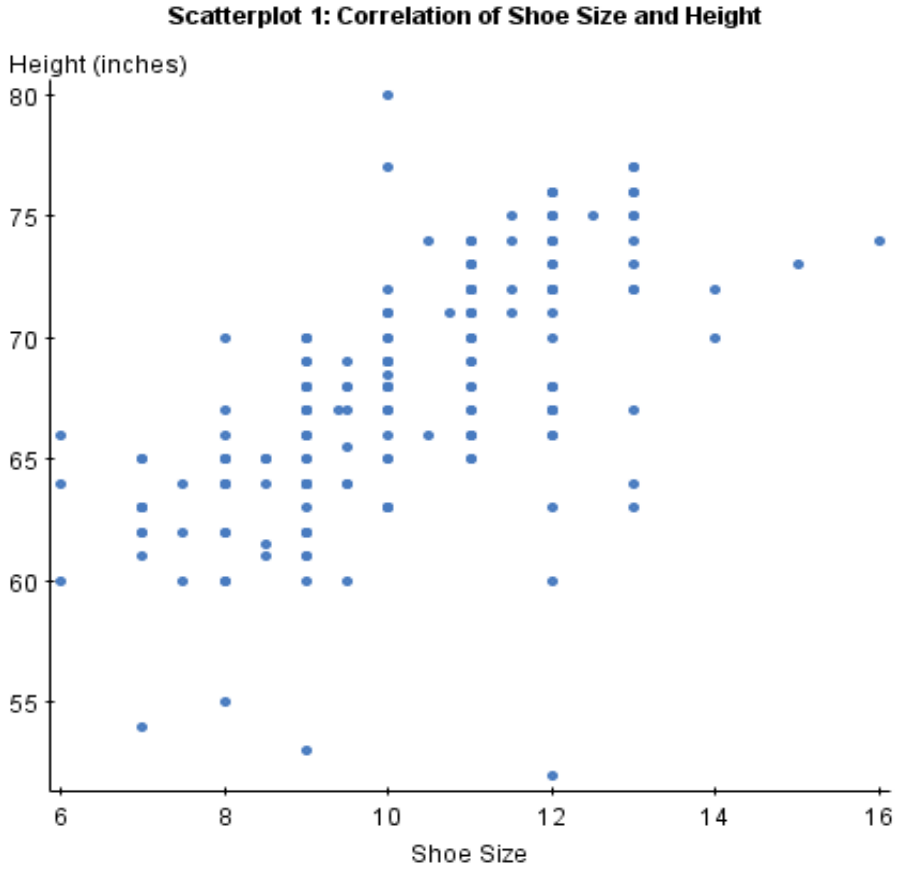
- Testing logic
- Check edge cases

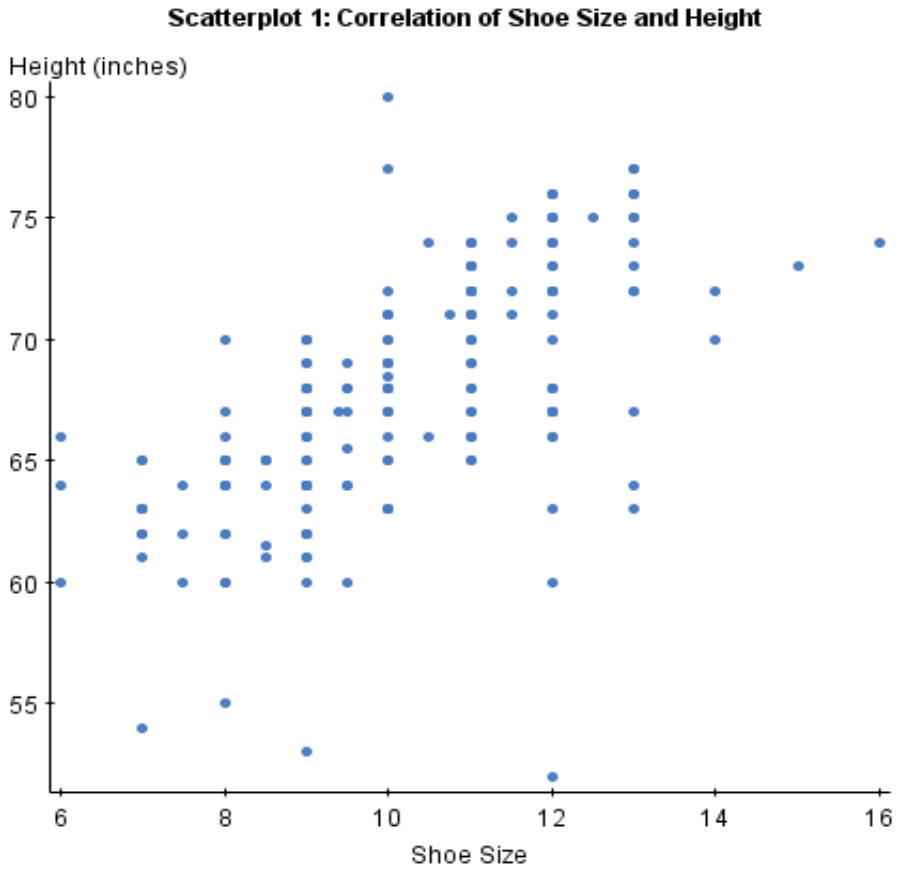
- Statistical testing
- Check average performance

Evaluating Performance



Evaluating Performance

- Need labeled examples
  - Size: 9, Height: 61
  - Size: 12, Height: 66
  - Etc.



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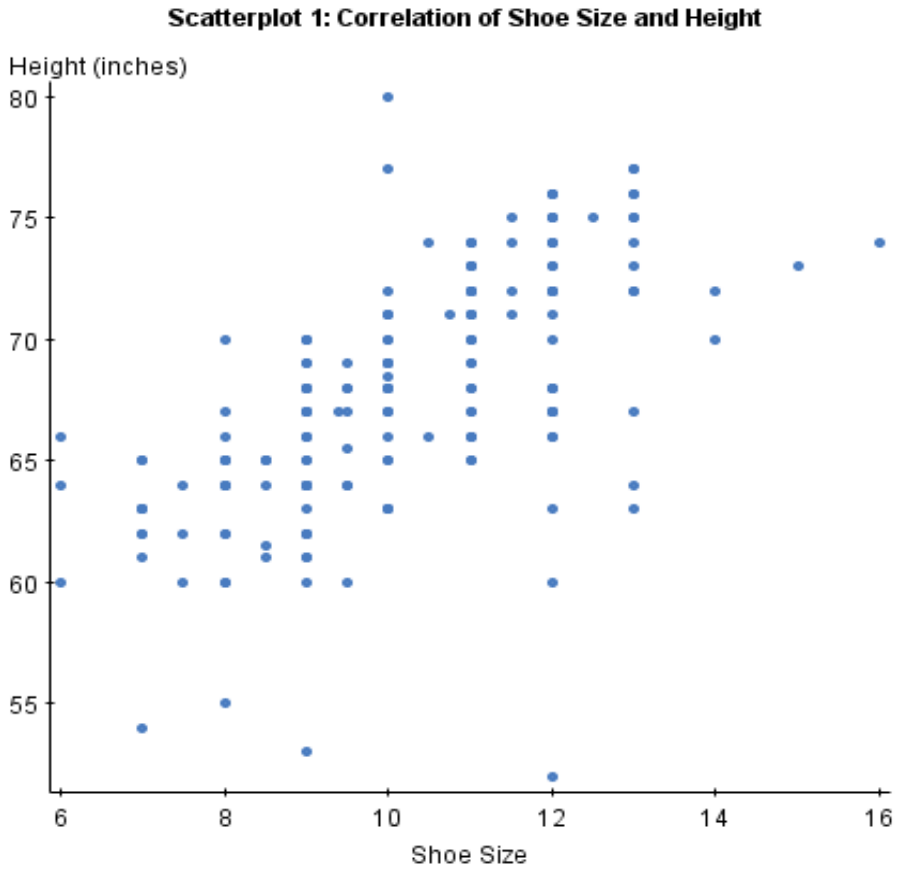
- Compare function output (predictions) to labels
  - “Error” or “Loss” or “Cost”



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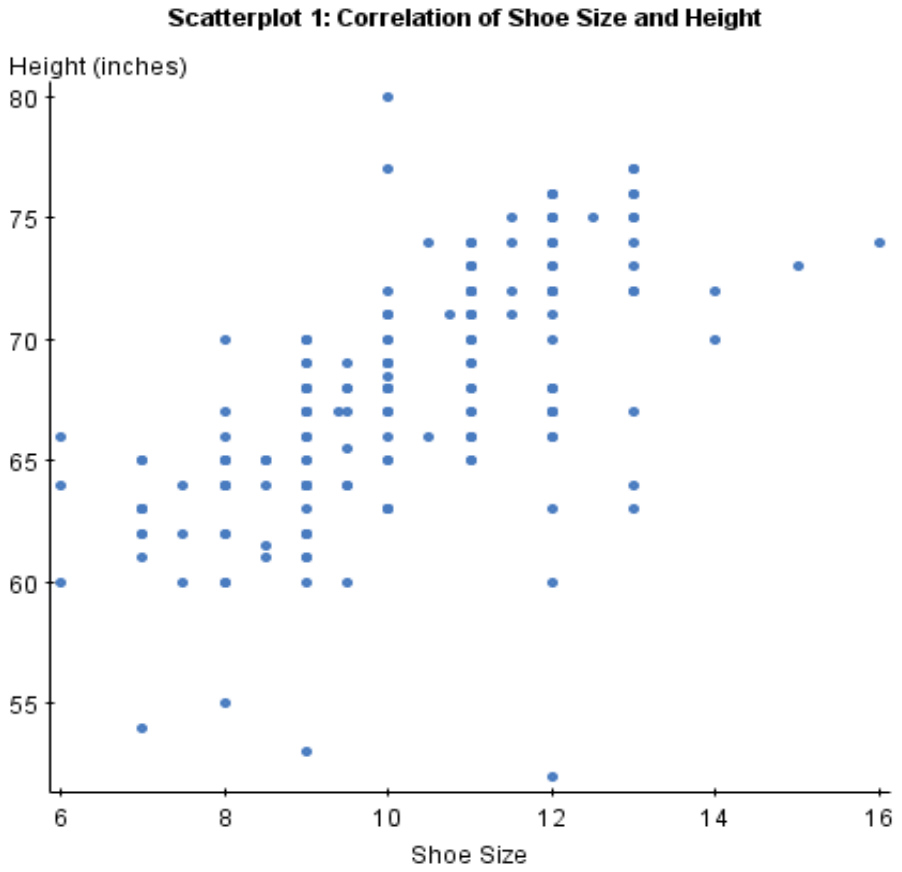
$$MSE = \frac{1}{|Y|} \sum_{y_i \in Y} (y_i - \hat{y}_i)^2$$

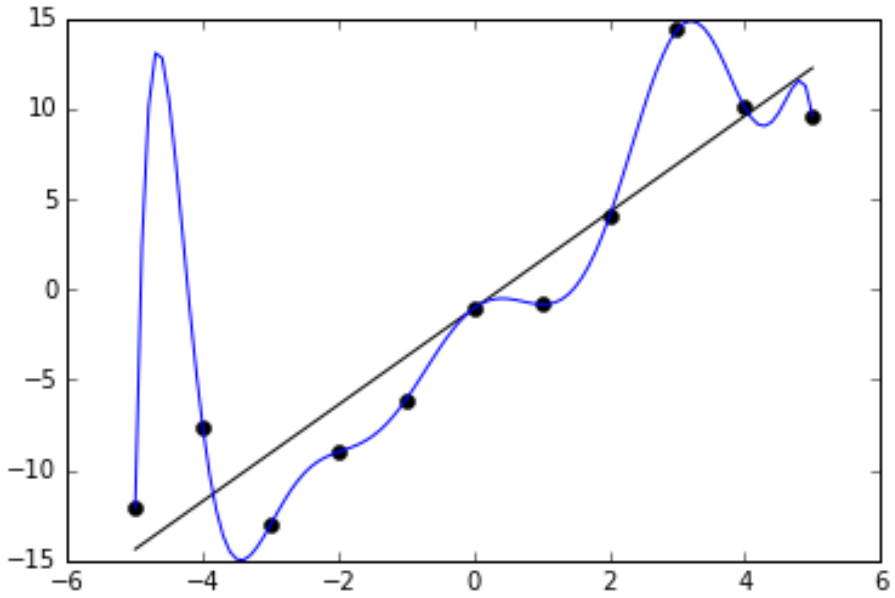


The End

Generalization

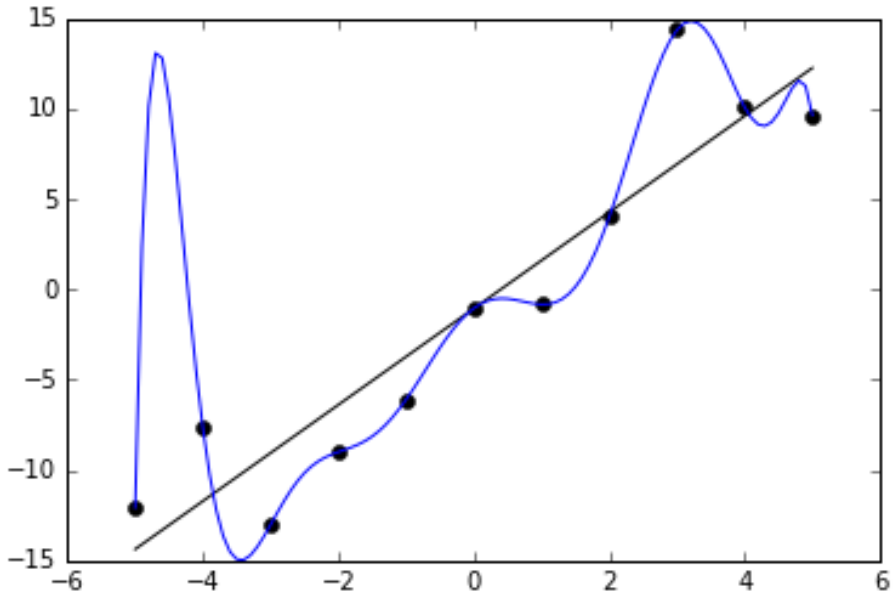
Predictions

- Suppose the points are the labeled examples



Predictions

- Suppose the points are the labeled examples
  - Are both black and blue lines possible models?



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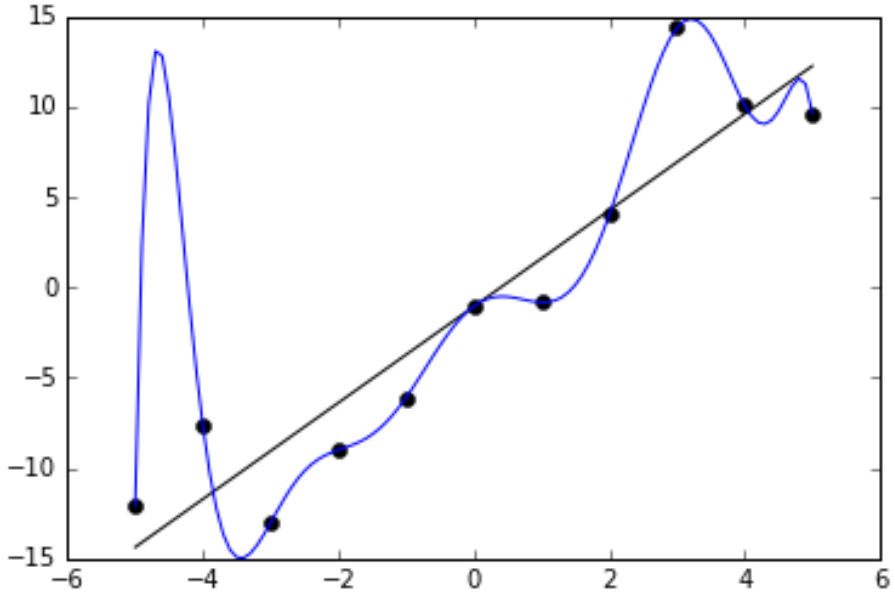
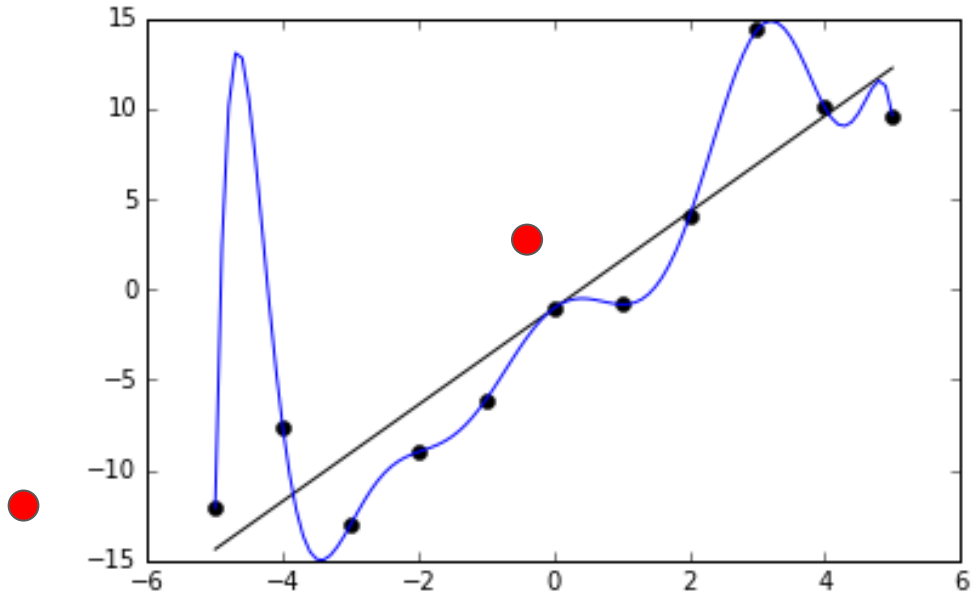


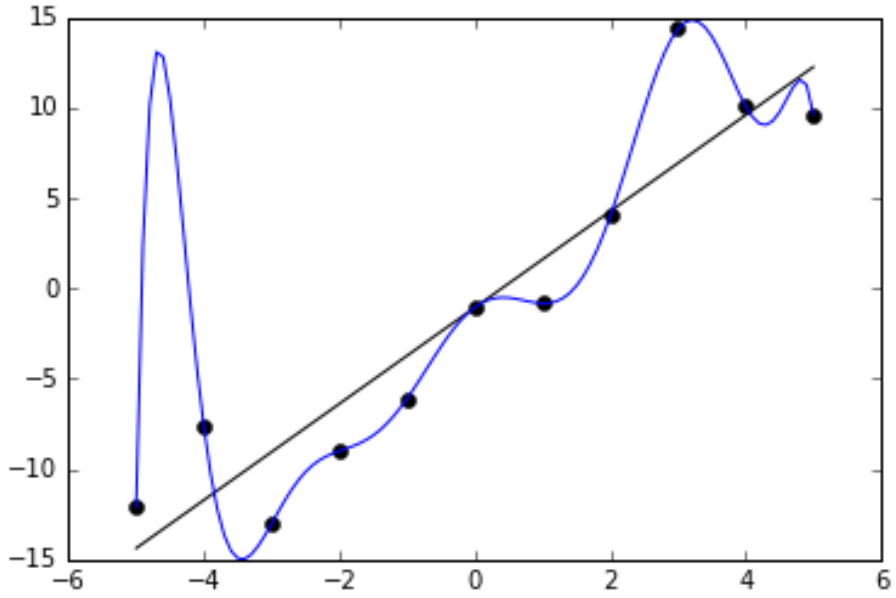
Predictions

- Suppose the points are the labeled examples
  - Are both black and blue lines possible models?
  - Which is better?
  - How do they perform with some new data?



The Train/Test Split

- Models are useful for making new predictions
  - This is called ***generalization***



The Train/Test Split

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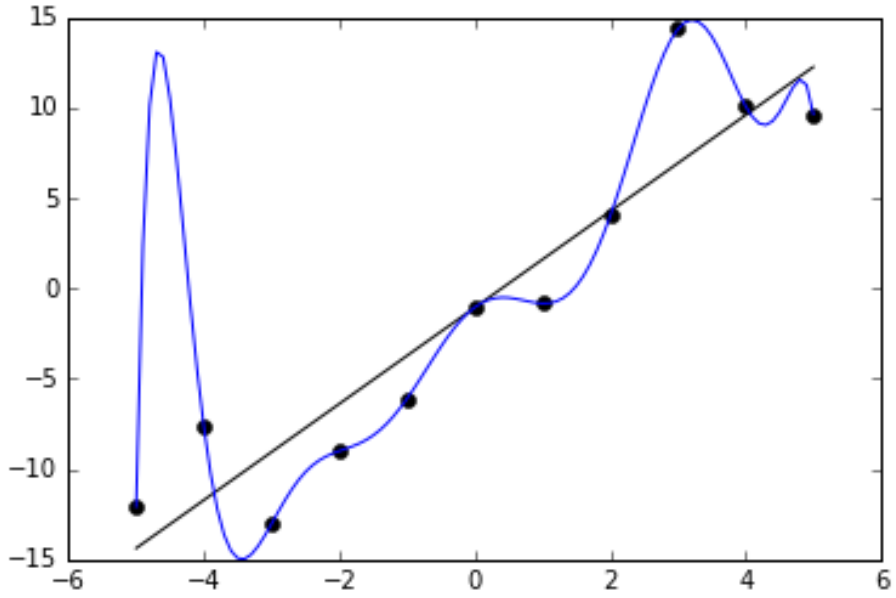
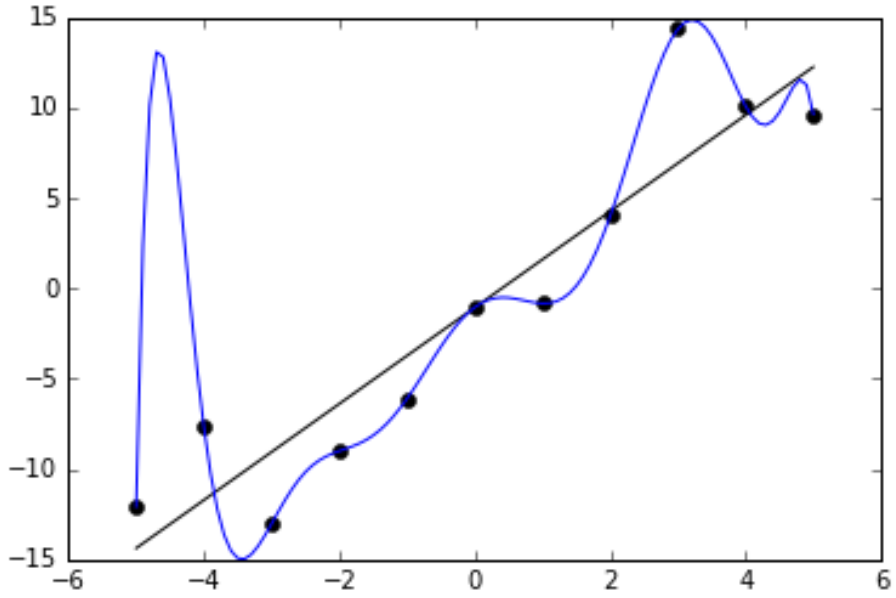
  - Could be a random split
  - Could depend on other properties of the data



The Train/Test Split

- Models are useful for making new predictions
  - This is called ***generalization***
- Simulate this by splitting data into train and test
  - Could be a random split
  - Could depend on other properties of the data
- Blue model is an example of ***overfitting***



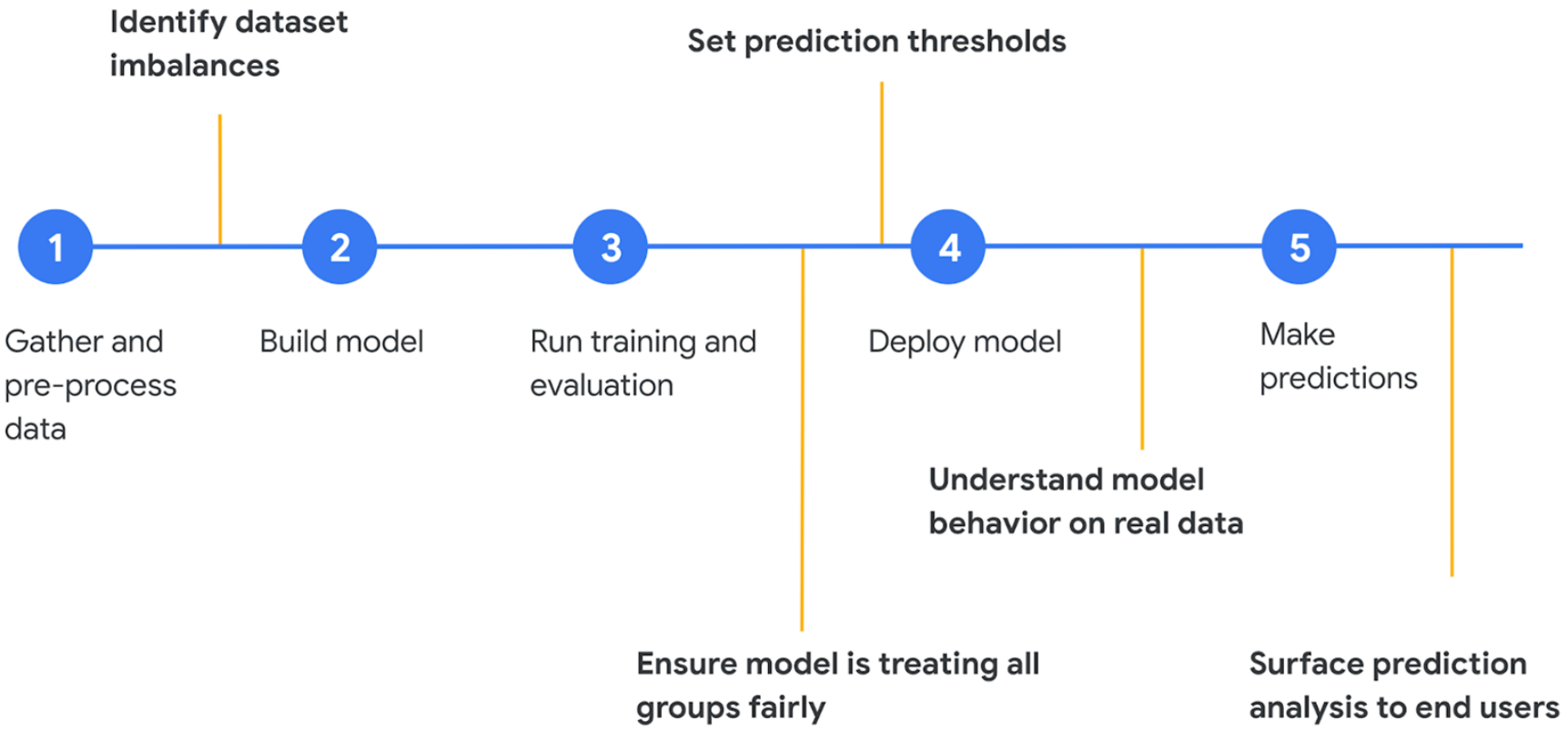
The End

Machine Learning Framing

Summary So Far

- You're already familiar with *logical* functions
  - Outputs are typically deterministic
  - Testing is logical and typically checks extreme cases
- ML is about learning *statistical* functions from data
  - Outputs are predictions
  - Testing is statistical and typically checks average case
- ML depends on labeled data
  - Behavior of the model reflects the data
  - Need separate test data to evaluate generalization

Machine Learning Framing



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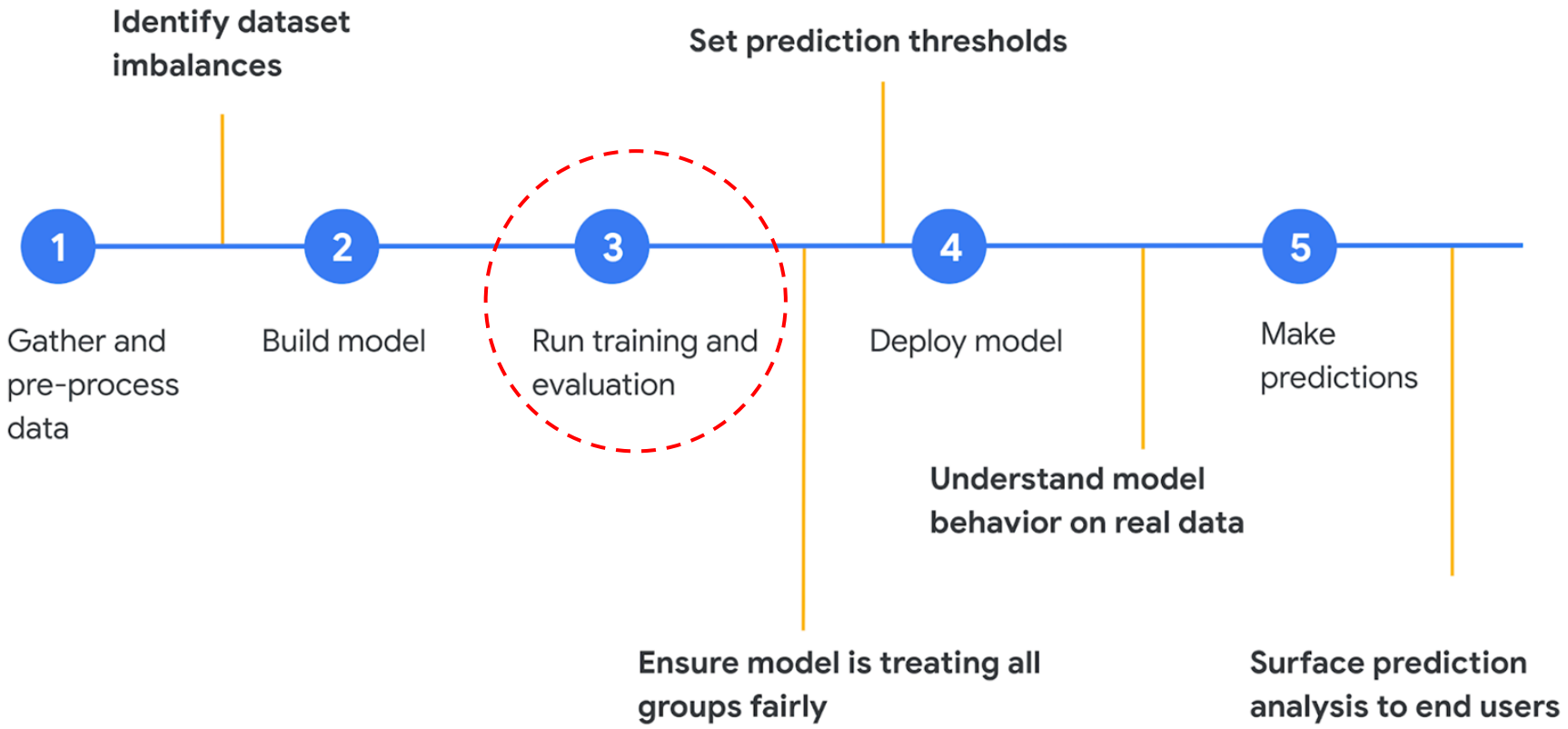

Framing: Defining a Task

- What are the inputs and outputs?
- What is the labeled data?
- Considerations for train/test split?
- How will your function be used?
- How will you evaluate predictions?
- What is a baseline predictor?

The End

Lung Cancer Screening

Example One

Lung Cancer Screening

- What are the inputs and outputs?
- What is the labeled data?
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Google

What are the inputs and outputs?

- Input: CT images
- Output: cancer probability
- Output: image regions and probabilities

Google

What is the labeled data?

- Scans annotated by human experts

Google

Considerations for train/test split?

- No patient with scans in both train and test

Google

How will your function be used?

- By doctors
- By patients
- By insurance companies
- Does training population match usage population?

Google

How will you evaluate predictions?

- Classification accuracy

Google

What is a baseline predictor?

- Always predict ‘no cancer’

Google

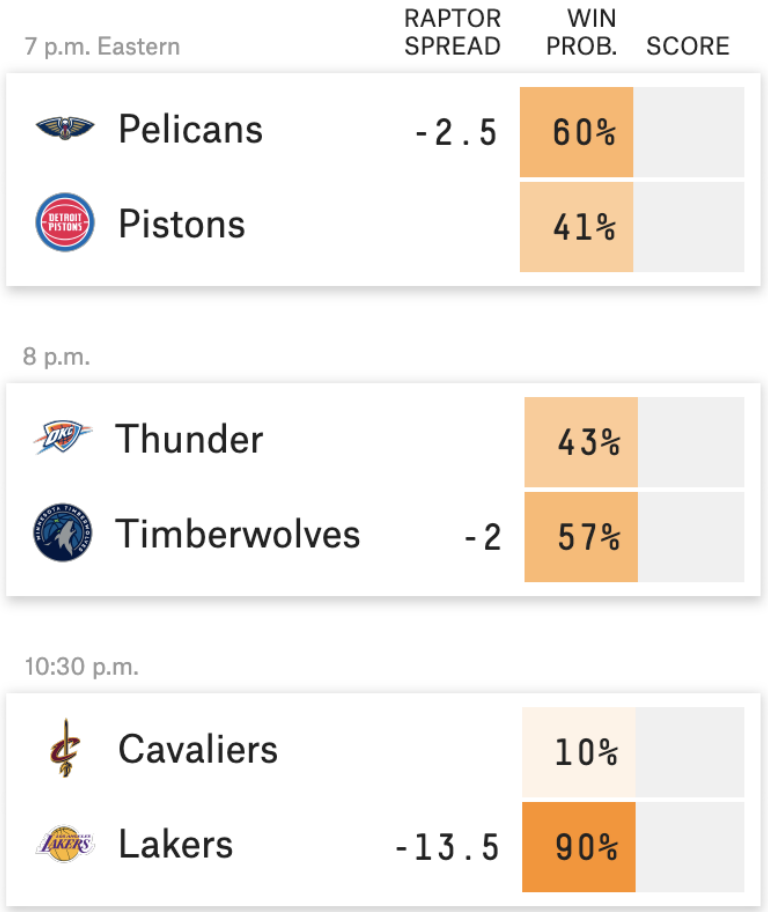
The End

Sports Outcomes

Example Two

Basketball Predictions

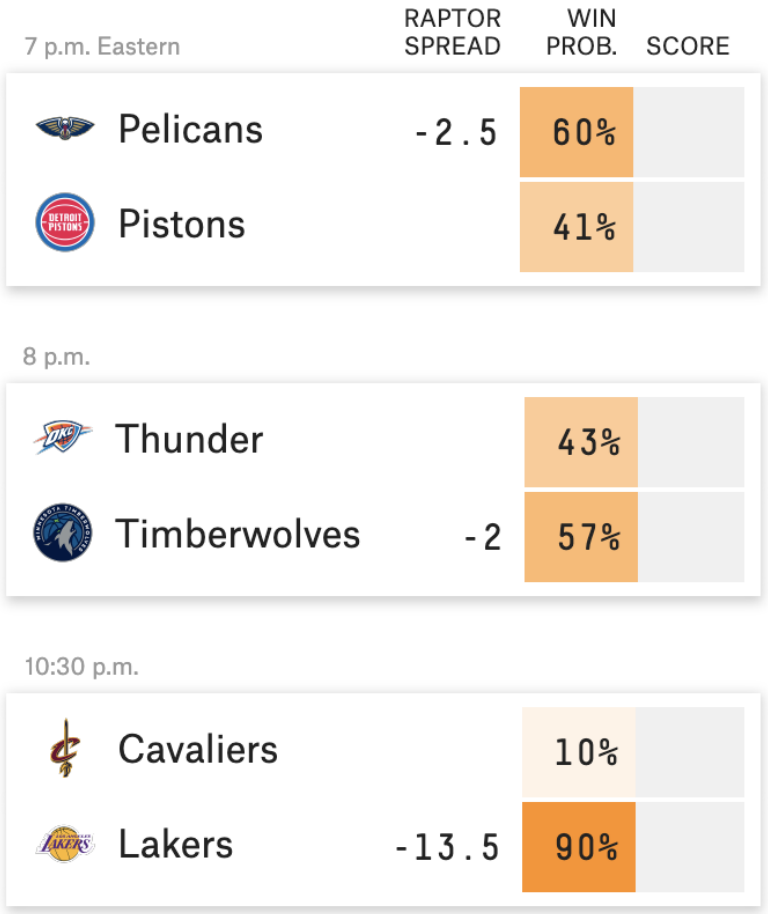
- What are the inputs and outputs?
- What is the labeled data?
- Considerations for train/test split?
- How will your function be used?
- How will you evaluate predictions?
- What is a baseline predictor?



FiveThirtyEight

What are the inputs and outputs?

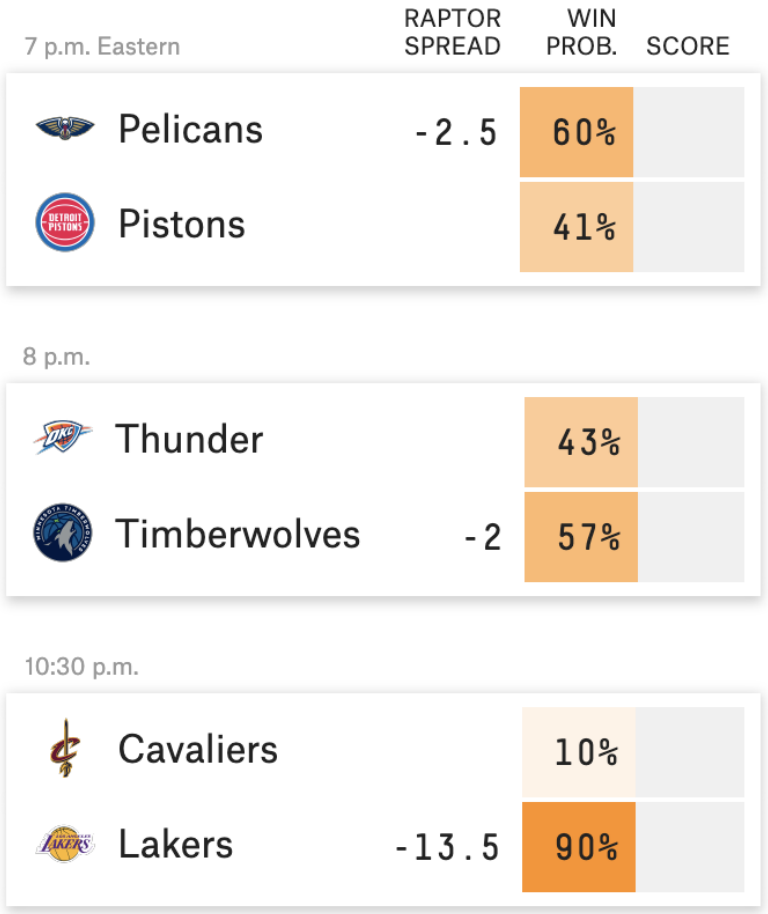
- Inputs: team1 and team2
- Outputs: win/loss
- Outputs: point difference



FiveThirtyEight

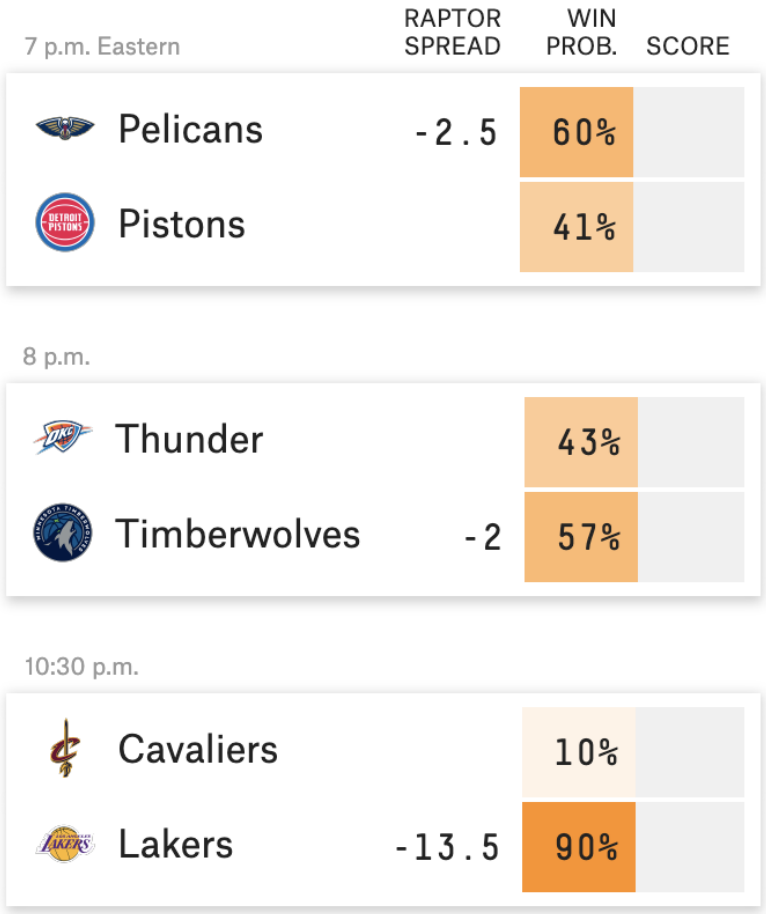
What is the labeled data?

- Previous games and results (from the current season)



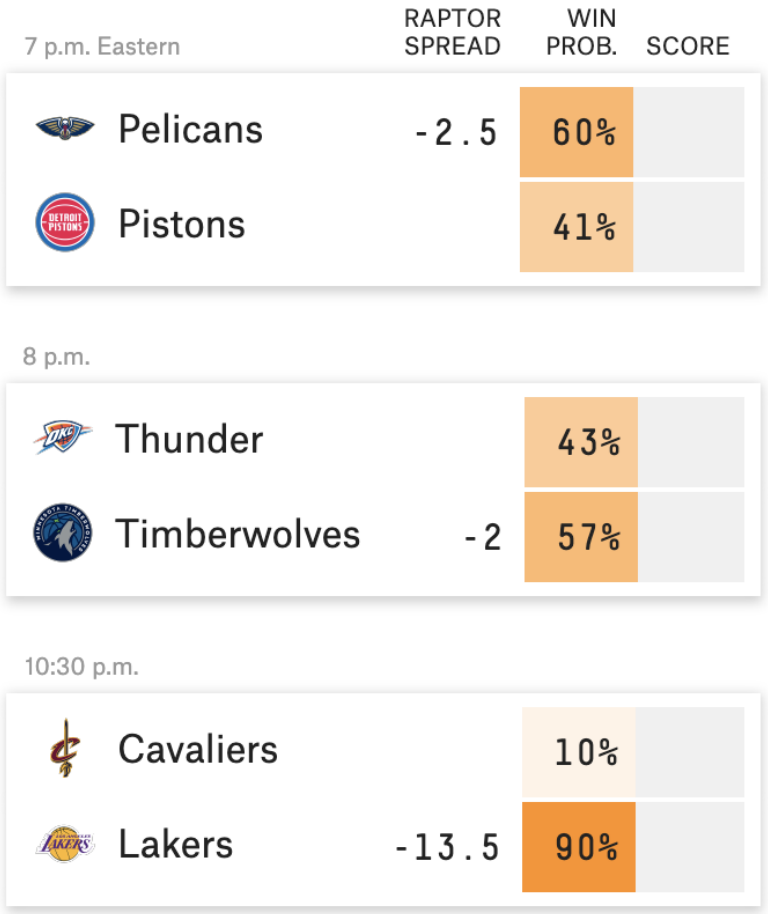
Considerations for train/test split?

- Use past games to predict future results (rolling predictions)



How will your function be used?

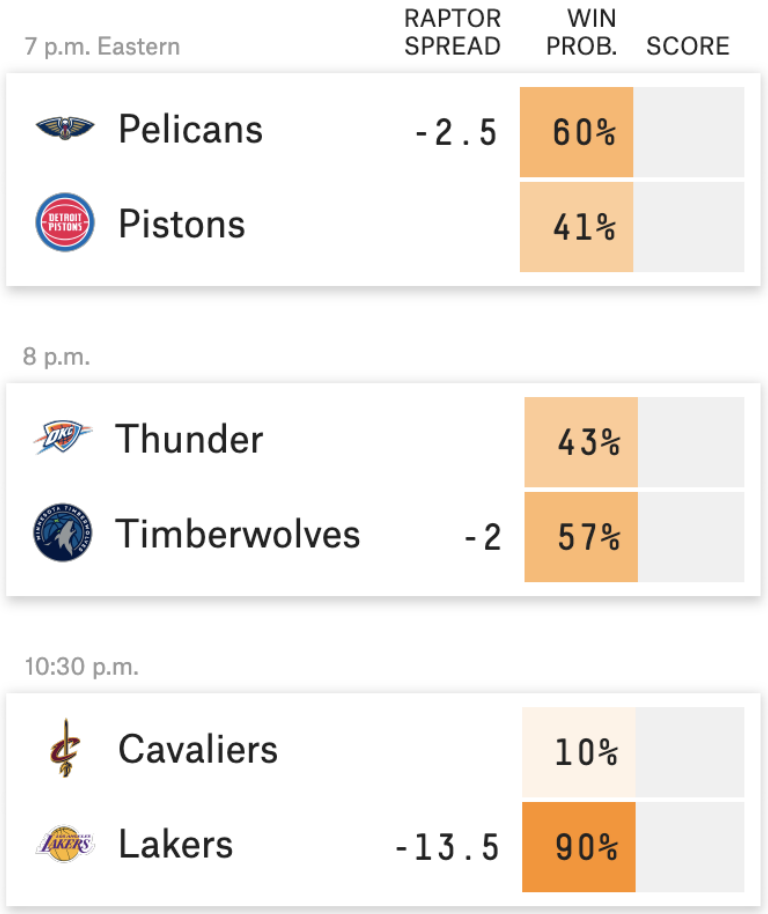
- Gambling: setting lines



FiveThirtyEight

How will you evaluate predictions?

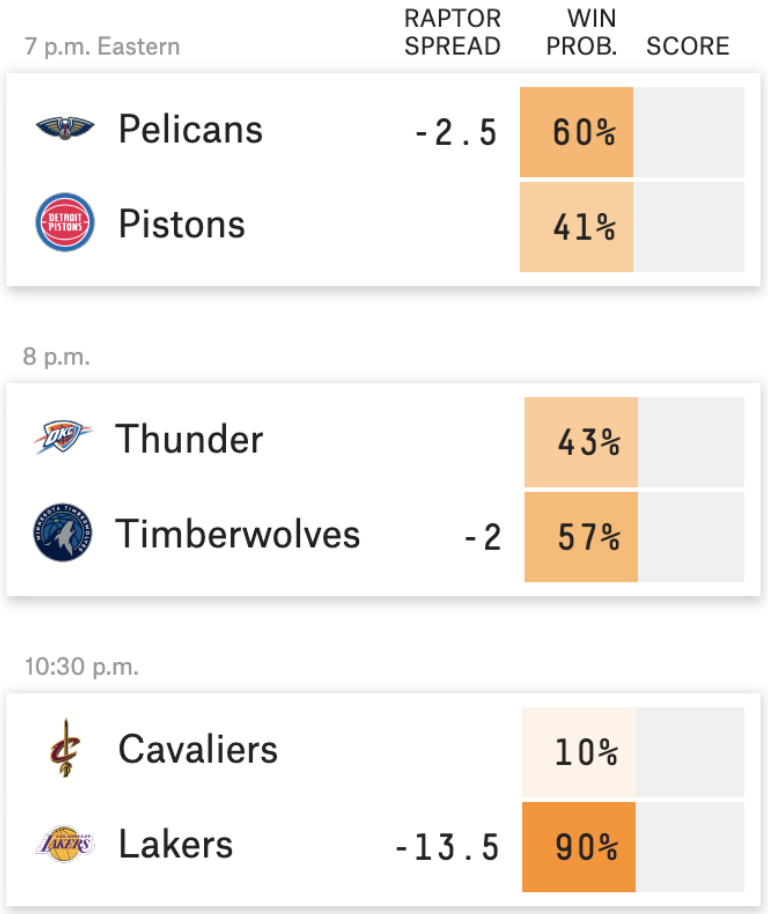
- Accuracy, MSE



FiveThirtyEight

What is a baseline predictor?

- Team win/loss records



FiveThirtyEight

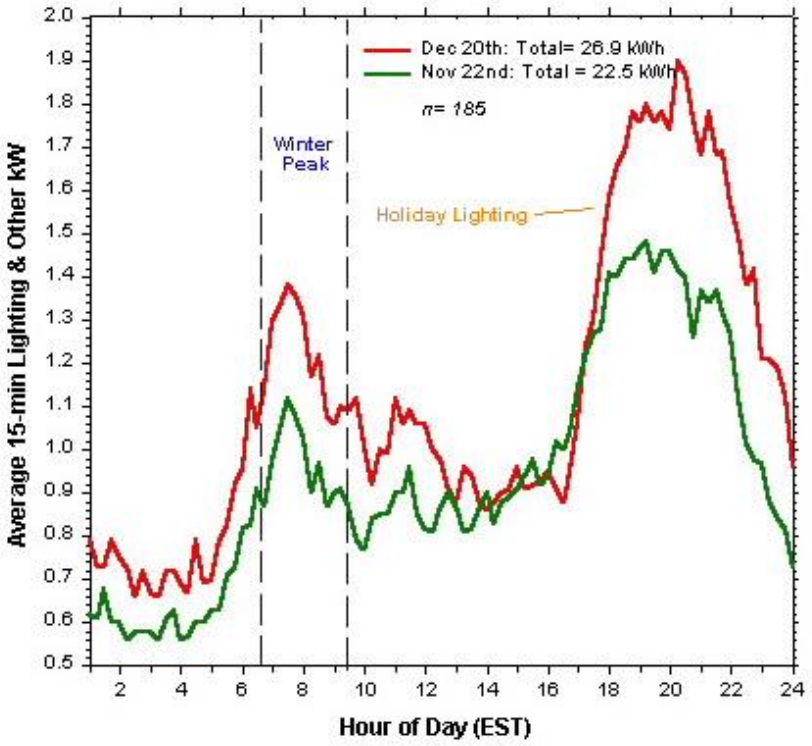
The End

Energy Usage

Example Three

Energy Usage

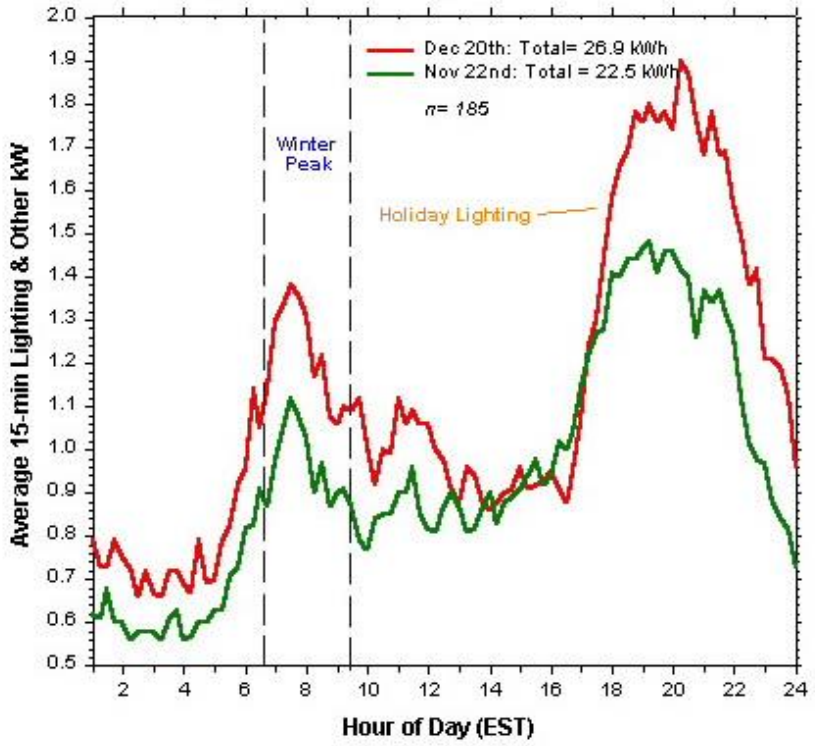
- What are the inputs and outputs?
- What is the labeled data?
- Considerations for train/test split?
- How will your function be used?
- How will you evaluate predictions?
- What is a baseline predictor?



FSEC

What are the inputs and outputs?

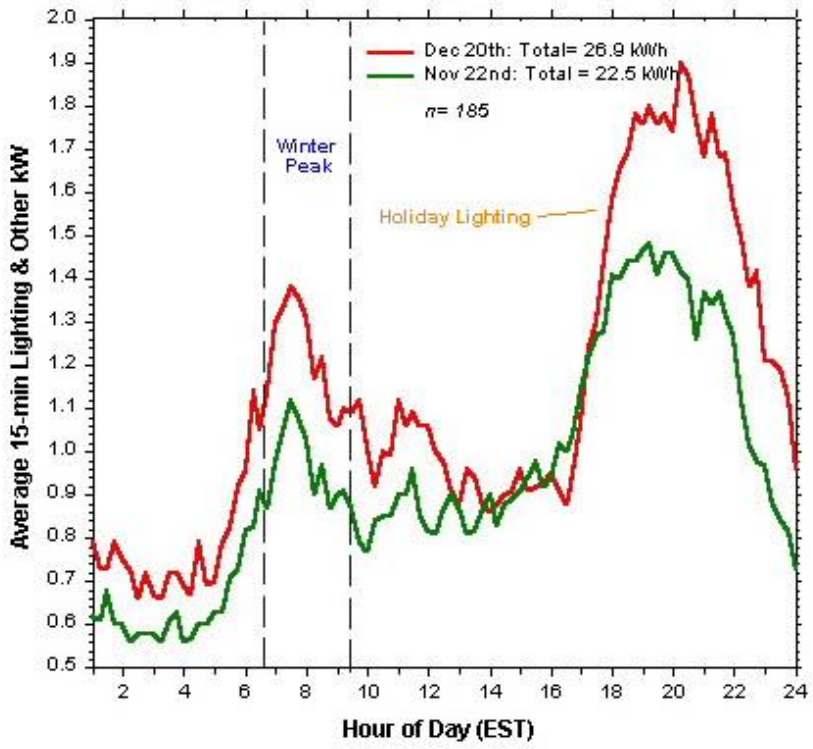
- Inputs: date, time, weather (15-minute intervals)
- Outputs: energy usage



FSEC

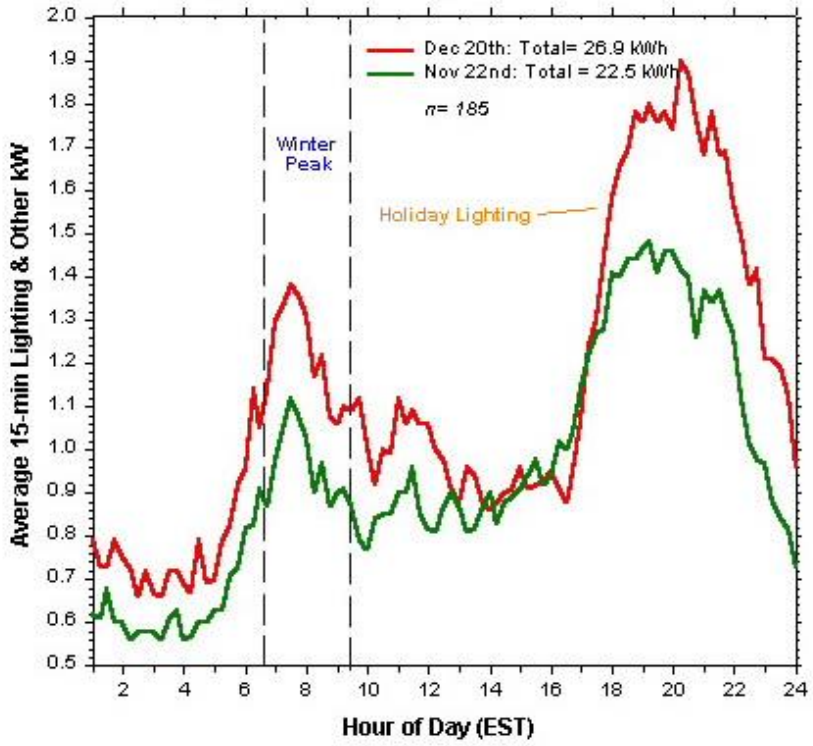
What is the labeled data?

- Previous observations



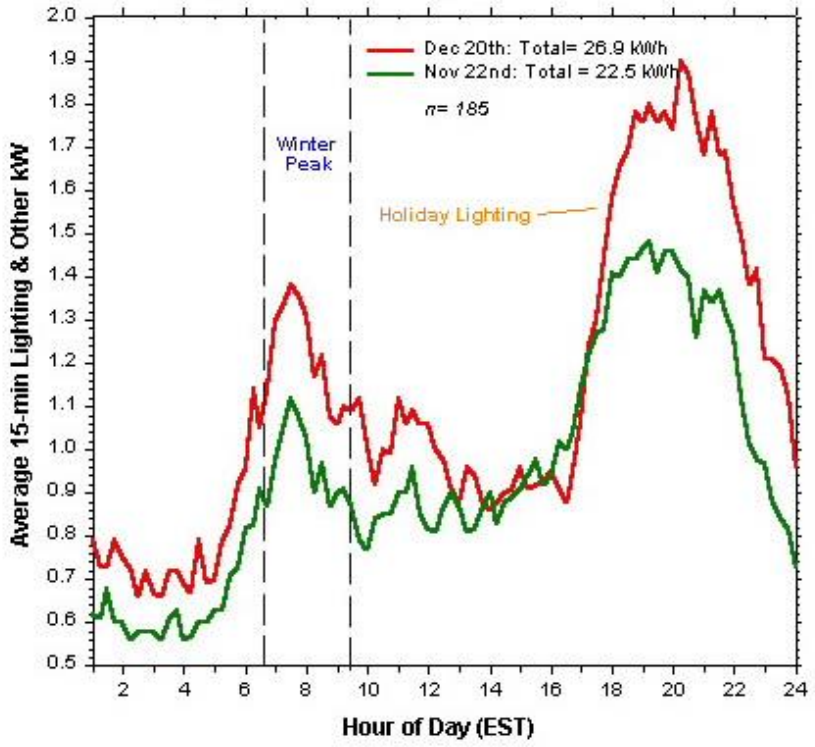
Considerations for train/test split?

- Rolling predictions



How will your function be used?

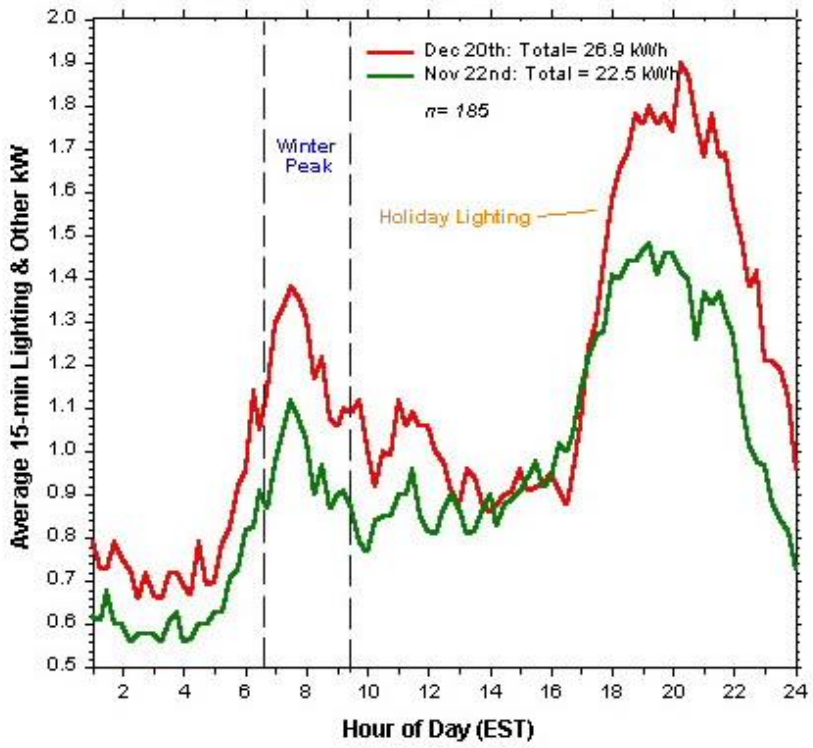
- Coordinating mixture of power sources



FSEC

How will you evaluate predictions?

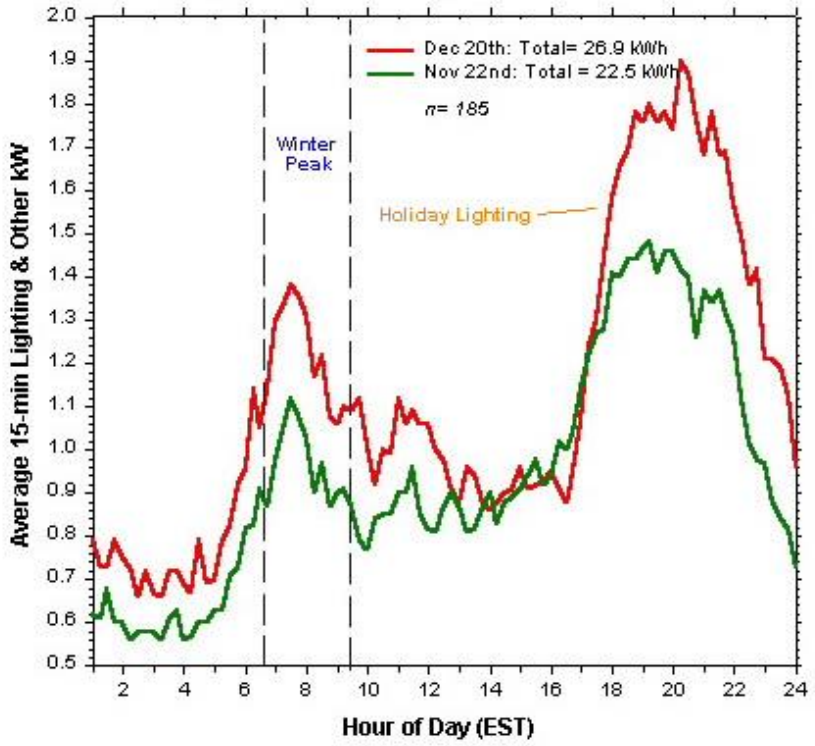
- MSE



FSEC

What is a baseline predictor?

- Average usage



FSEC

Review

- What is a **function**?
- What is a **model**?
- What is meant by **generalization**?
- What is **overfitting**?
- Why do we need a train/test split?
- Why do we want a baseline?

The End